Article

The Compositor Tool: Investigating Consumer Experiences in the Circular Economy

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Abstract: Humanity is living through a crisis that sees our way of life exhausting the resources of the earth and ourselves. The fashion sector shows the negative impacts of conspicuous consumption on our socioenvironmental wellbeing. Despite citizens' growing awareness of their responsibility within consumption cycles, they reveal concerns about their lack of understanding and the support required for them to become agents of responsible consumption. The Circular Economy flourishes as a conceptual approach to help society transition to a more sustainable existence. This paper explores how emerging creative technology and interaction design might support a shift in the role of citizens in the Circular Economy. We performed a design inquiry that investigated the moment of acquisition via configuration of products, storytelling, and multimodal interaction techniques for the creation of experiences that could catalyse citizen-consumers to become custodians of materials. We developed a retail-based concept tool—The Compositor Tool—with which we ran a user study to investigate new experiential ways that consumers can participate in materials' circularity. The study highlighted how experience design and new interaction techniques can introduce circularity as part of consumer experience by forging deeper connections between people and products/materials and enabling consumers to have more creative and informative material engagement.

Keywords: circular economy; design research; cultures of consumption; materials experience; material engagement; interaction; creative technologies

1. Introduction

Imagine that there is a new type of shoe in the market that is high-quality, long-lasting, and allows for the replacement of parts for functional or aesthetic reasons. These shoes are designed in a modular way so that people can experience and choose the materials they will be made of, and in doing so, they can explore their provenance, properties, and potential future lifecycles, which offers a glimpse of potential impacts on these shoes' end-of-life as well as a good grasp of their feel and quality. The modularity also allows for easier repair and replacement of parts and facilitates the recycling of materials.

This scenario is at odds with the current linear fashion system. The fashion sector is one of the highest polluting industries in the world. Within the paradigm of the 'take-make-dispose' model [1], resources are used to manufacture a product, with little consideration of the life of such resources beyond the selling point, i.e., consumers are left with the problem of disposal. This situation is exacerbated by the fast fashion model which promotes conspicuous consumption—fuelled by a market that exploits the need for immediate satisfaction, novelty, and status building [2]. This leads to types of user engagement that are detached, which has implications for how people care and dispose of products. UK citizens discard one million tonnes of out-of-fashion or damaged clothing items per year [3] a third of which ends up in household bins [4] at a disposal cost of £34.6 million [5], and

two thirds of which are collected via charities or clothing banks [3]. The UK government has set a target of achieving 'zero avoidable waste' by 2050 [6]. A recent report by the British Fashion Council's Institute of Positive Fashion suggests that to achieve this target, consumer demand for new, physical clothing needs to be reduced by 50% [7].

The above scenario would be plausible in a Circular Economy (CE). The CE is gaining momentum as an alternative proposal and strategy to achieve sustainability and builds on the premise that materials should be kept in use for as long as possible, whilst retaining the highest possible value [8]. This has direct implications on product longevity and requires design strategies to achieve it, critically, in considering ways to slow down and close resource loops [9]. Keeping products and materials in use for as long as possible has implications on the use phase, and the role of the user becomes critical in creating and maintaining value [1]. However, with most of the effort being placed on the technical challenges of enabling a CE, there are as yet no strategies that enable the user to actively participate in materials circularity, and there is limited research dedicated to informing design in this space [1], despite acknowledgment of the importance of users' actions on product longevity [10]. Citizens still find few opportunities for closer engagement throughout the duration of product use: being cut-off by the guiding principles of the linear model that mostly considers the point of acquisition as practically the end of a relationship (as summarized Bakker et al. (p. 31), 'design something, manufacture it at the lowest possible cost, sell it at the highest possible price and forget about it as soon as feasibly possible.' [11]). Further, at the end-of-life, take-back schemes and recycling remain a distant and opaque way of feeding materials back into the loop, which ultimately still feels similar to disposal [12]. Both the moment of acquisition and the disposal are transformed in a circular economy, away from the linear model, since 'taking' and 'disposing' can take several forms. Research has been found in relation to the disposal of products in a circular economy [12], while a gap has been highlighted when it comes to the moment of acquisition [1]. In a circular economy, what is also referred to as the 'engagement phase' is faced with new challenges relating to the emergent types of business and ownership models and the perception of waste-based or recirculated materials/products [1].

There is a lack of structures that enable circular practices and poor communication about products/materials and their life span leaving citizens unsure about how to act. Citizens are becoming mindful of their personal responsibility to become more aware of what they buy; witness, for example, the popularity of rating Apps such as 'Good on You' that enable tracking of brands' scores in terms of ethical and sustainable credentials. Citizens are willing to spend more for responsible goods [13], and increasingly consider themselves responsible for tackling climate change more generally [14]. That greater awareness suggests a need to further support and empower citizens in relation to responsible consumption, something that is also predicated on the SDG 12-Sustainable Production and Consumption [15].

In effect, there is no practical guidance nor support in place for the facilitation of citizens to become key actors in the CE. Nonetheless, in a CE, citizens need to have a different relationship with their products/clothing and the materials in them. This need has been highlighted recently as a priority area for the UK to achieve systems change towards a circular fashion ecosystem; the Institute of Positive Fashion recommends 'consumer empowerment' as key for UK consumers "to make less environmentally impactful purchasing choices, value clothes, and make circular behaviours mainstream" (p. 6). The strategies recommended to achieve this include 'shifting consumer practices' (focusing on extended use and enjoyment), 'educate for circularity' (supporting informed choices and engagement in CE practices), 'digitise garments' (promoting wearing in the digital sphere as a dematerialisation strategy), and 'formalising skills' (reskilling for repair and maintenance) [7].

In this paper we respond to the CE imperative and to the sociotechnical context requirements for change presented above by exploring the means of promoting a change in cultures of consumption and adoption of circular materials. We hypothesise that creative

multimodal technologies will help to strengthen the role of citizen-consumers in moving beyond the limiting constraints imposed by the current linear model of consumption-use-disposal, to become custodians of materials, and active participants in a sustainable product cycle. Forging a closer relationship between consumer and materials can diversify the types of pleasure they experience and help to promote new product cultures. We investigate this through our research question, "How can designed experiences catalyse citizen-consumers to become custodians of materials, and therefore stakeholders in material circularity, as a circular design strategy?".

To explore this question, we developed and built a retail-based concept tool—The Compositor Tool—with which we ran a user study to investigate new experiential ways of understanding materials' past, present and future. The aim was to inform how consumers select and configure materials to build their own shoes, as outlined in the scenario described above. We built on research that shows the importance of engaging the body in experiencing textiles [16] and materials more generally (e.g., research in materials experience shows how expert and non-expert designers overcome the physical separation from materials through 'tinkering' [17–19], which has implications for the ways of knowing, exploring, and thinking [20]). The Compositor Tool engages citizens in multisensory experiences and storytelling that involve the materials in products. The aims are to enable consumers to (i) understand biobased circular materials and their reactions to them, (ii) more actively engage in the co-creation of products, and (iii) bring awareness of, and slow down, the process of consumption. We ran this feasibility study using a low-fidelity protocol involving analogue and digital means in order to enable citizens to have a deeper sensory engagement with materials. This was achieved by exploring their present form, and projecting them back into the past (e.g., provenance) and into the future (e.g., performance, care). These were used to provide compelling experiences related to materials, and to support people in their selection and configuration in engaging and playful ways. Through the study we observed if and how new interaction techniques might enable consumers to have more embodied, creative, and informative interactions, and to have a deeper connection with products and materials. We then extrapolated from this to make conclusions about consumers being custodians of materials.

2. Background

2.1. Cultures of Consumption (and the Role of the Consumer)—From Linear to Circular Economy

Consumer cultures can be traced back to the beginning of human societies; objects have always been a necessary part of people's lives. The consumption of objects helps humans to transmit culture. Displaying, trading, and passing objects down through generations enables culture to reach beyond the immediate group of people who created it [21]. The role of the consumer in patterns of consumption, and their relationship to the product, is dynamic and changes in relation to various contexts. One clear difference in how we consume goods today in comparison to earlier cultures is in the separation of production and consumption. To broadly generalise: previously, consumers used 'history-thick' ([21], p. 4) objects. They knew how, by whom and where objects were made. Since industrialisation and the division of labour, consumers have found it more difficult to ascertain the provenance of their products. For Marx ([22], p. 3), this led to the alienation of the producer from their product and from the act of production, and of the consumer from the producer, instead mediated by an interface (the capitalist). Instead of direct engagement between consumer, producer and product, consumers are asked to assign value to companies and brands in a market-driven context.

The role of the consumer shifts again if we envisage a transition from a linear to a Circular Economy. In a linear economy, products are understood and treated as finished, relatively permanent solutions until they break or become obsolete, and become waste and 'disappear' out of sight. From a circular perspective, products can be understood as temporary constellations of materials that have come together to form a solution for a user over a particular period. In that context, the user will be a key actor in ensuring that the

product is successfully transferred between these cycles of use: they might send the product back to the provider after use (Cyclon shoe subscription [23], Patagonia Worn Wear [24]), or pass it on to other users (Fashion rental companies; Rent the Runway [25], Rotaro [26], Onloan [27], Vigga babyclothes subscription [28]), or perhaps recognise, initiate, or facilitate upgrades (Nudie jeans [29]). Once a product has reached the end of a cycle of use, the materials can be disassembled and moved to form other products in a new lifecycle, with a new user. For citizens and the consumption of products this means:

(*a*) *a different relationship between consumers and products*, characterised by either very long term (if it is a long-lasting personal product) or temporary ownership models (if the product is designed to be returned, shared, rented, or swapped). The new circular definition and understanding of what a product is—temporary constellations of materials, components, services, etc, that have come together to form a solution for a user over a particular period, i.e., a temporary assemblage [30]—means a new understanding of the user's role. This can happen at many scales: intact product components could move directly to form new versions of the same product with as little use of resources as possible (e.g., the body of a jacket is cleaned and used directly with other used intact parts in a new jacket), or, at a much more detailed scale (e.g., textile fibres from a dress are chemically extracted and woven into the fabric of an entirely different product such as a car seat). The point is: the materials move to form new useful constellations [31]. The consumer is never the last or only person using this object and/or its materials. One consequence of this implicit model of custodianship over ownership is the shift in relationship between the consumer and the product, and the requirement for the consumer to personalise and 'inhabit' the product, especially if it's on a more temporary and time-restricted basis. New digital manufacturing technologies such as 3D-knitting, embroidery, 3D printing and CNC-cutting can all contribute to the personalisation and customisation of products, enabling consumers to become active participants in the production, personalisation, and upgrade of products [32,33]. Chris Anderson uses his concept of 'The Long Tail' to describe this shift away from mass market buying towards more niche or personalised buying; the value chain is extended by making very small providers, even individual consumers, part of the economy—creating a 'long tail' part of the market where companies can realise significant profits by selling low volumes of niche items to many customers, instead of only selling large volumes of a reduced number of popular items [34].

(*b*) *a different relationship between consumers and brands*, characterised by multiple channels and moments of interaction (repair, upgrade, swapping, take-back, etc.) along the lifecycle(s) of the product. In a linear economy, brands focus their efforts on pre- and during consumption experiences, with the point of acquisition practically marking the end of the relationship, and with post-purchase interactions with consumers being very limited, mostly only happening in cases of product failure. Talia Hussain describes the linear retail interface as ' . . . a one-way transfer from the sphere of production to the realm of consumption.' ([35], p. 6). In contrast to this, Hussain also describes that in a circular economy, 'the sale is merely one of many types of market interaction.' ([35], p. 6). Interactions such as repair, reuse, recycle, remanufacture, and take-back systems, are essential to circularity, but often these depend entirely on consumer behaviours. What consumers do with products after they acquire them is critical to keeping materials in the loop for longer and at their highest value (economic, societal, environmental). Hence, in a circular economy it is in the interest of companies to facilitate users' contributions to keeping materials in the cycle ([36], p. 4). Consumer behaviour and practices therefore become a potentially powerful catalyst for change [37]. As consumers facilitate the material flows, they temporarily take on the role of a 'caretaker' or 'custodian': living with and looking after an object, wherever possible/relevant enhancing it, and facilitating its flow to another cycle. This new role of consumers presents many opportunities, which so far have been little researched in relation to fashion products [38–43].

In this sociotechnical context, the role of the consumer is seen to transition to the 'prosumer': in contrast to the consumer who engages only passively in the economy and

is poignantly described as the 'end-user', prosumers participate in the economy because they demand transparency, share their reviews of products, or enter the market from the position of the seller as seen on peer-to-peer retail platforms [44].

2.2. Engagement with Materials and Tools to Facilitate It

As seen in cultures of consumption, with industrialization and globalization, people became distant from the making of materials and products. However, throughout history people have used materials to make things by hand, which makes the process more tangible as they can sense aspects of e.g., fit, texture, and sizing [21]. Moreover, people have also relied on physical interaction to understand the design and quality of products, for instance, handling was crucial for shoppers' browsing activities in the 18th century, to gain "understanding of objects, particularly in terms of design, quality and workmanship" ([45], p. 3). Additionally, the incorporation of tactile elements in communicating products is seen to increase emotional responses that may influence decision-making [46].

Indeed, in product, textiles, and fashion design fields the importance of material experimentation and engaging physically in making with materials is widely acknowledged as critical for understanding, selection, and creative engagement with materials [47–49]. Research also shows the importance of embodied engagement with materials more generally, e.g., through the important concept of 'tinkering' with materials, research in materials experience shows how expert and non-expert designers become closer with materials [17–19]. In all these cases, embodied engagement with materials has implications for the ways of knowing, exploring, and thinking [20].

Textile-based products are considered a high-involvement product category that needs to be evaluated through multi-sensory channels (i.e., via touch and sight [50]). Indeed, touching fabrics is a multi-sensory, emotional, and cognitive experience, which is of importance to both experts [16] and non-experts [51,52] in appreciating and understanding fabrics. Research has also shown that consumers' perceptions of textiles are reliable when compared to designers [51], but that they show limitations with language or skills to articulate these perceptions. On the other hand, designers' communication in relation to textiles experiences is frequently multimodal, involving verbal, visual and physical means to express and communicate across teams [53]. This evidences that these are difficult processes to articulate, and that the knowledge mobilised in such processes is heavily innate (reliant on designers' sensibility and intuition) and tacit (acquired through training and experience) [54]. It seems that consumers would need support to make such processes an intuitive and integral part of their experience of understanding and engaging with materials.

Previous research has proposed a framework to design 'Radically Relational tools' that can support the textile experience and selection, particularly in focus (on the body and on the textile interaction), elaboration, articulation, and communication of the haptic experiences with textiles [55]. The tools have led to promising processes that can generate embodied knowledge grounded in the sensations and affective responses to materials. We build on this body of work that shows the importance of engaging the body in experiencing textiles for design and highlight this as an approach to bring consumers closer to materials.

2.3. An Altered Consumer Journey: Emerging Technologies and New Experiences in Retail

Technological transformations in retail offer interesting opportunities to support a transition into greater consumer awareness and to mitigate the effects of conspicuous consumption. Rapid shifts in behavioural retail trends (consumption experiences, peer-to-peer swapping/trading [44], sharing on social media) and growing e-commerce drives fashion retailers away from high-street stores towards offering memorable experiences related to the personalisation of goods [56]. Indeed, the current retail reconfiguration in the light of a considerable increase in e-retail presents opportunities such as repurposing the brick-and-mortar space and what in-store experiences offer. In addition, continuous developments in creative technologies (e.g., digital manufacturing) will allow production in retail spaces, and enable SMEs to offer personalised products on the high street [57])

while interaction design (e.g., Virtual, Augmented and Mixed Reality, AI, robotic assistance, etc.) will bring new opportunities for brands and retailers to engage with consumers [58], who will be more actively involved in co-creation and design activities [59].

From a historic point of view, online shopping (first conceived in 1979 by Michael Aldrich) was concepted to reduce social disadvantage by offering services to the vulnerable and physically challenged [60] and indeed e-commerce is said to increase consumer welfare [61]: accessibility, price comparison and more transparent information gathering are the most obvious benefits. However, online, the appearance of a product dominates the selection process and central aspects such as touch, materiality, fit, and consultancy are considered only at a later stage. In this way, mobile, and social media retail have changed patterns of consumption. The disruption of the classic linear shopping experience of 'browsing, trying, buying' is one of the first aspects we are interested in: e-retail has rejigged the consumer journey and the moment one acquires a fashion product nowadays often overtakes the try-on, changing room moment, resulting in a devaluation of the moment of purchase. Simultaneously the monetary commitment is no longer a promise to the retailer because the online B2C relationship is frequently extended into return procedures, which result in post-purchase cleaning, product checks and repackaging, adding up to the environmental costs [62]. However, there are benefits in a culture of continuous engagement with the consumer beyond the point of sale: a side-effect of omni-channel culture, which can be explored in a CE where continuous engagement is so valuable. With the rise of new product cultures and alternative consumer needs, the supply chain and the underlying value system have undergone changes: on-demand production and customisation are responses which have set off a more participatory and inclusive user journey. We hypothesise that the latter have the potential to allow for a 'conversation' pre-purchase and a stronger bond between the buyer and the product—one less likely to result in the return of goods.

Newly emerging e-consumer habits also challenge common concepts of ownership, and it is important to note that the impact of the digital on the physical retail goes far beyond stealing its business. Instead, High Street retailers are taking note of the possible benefits it may hold. More is expected from a brick-and-mortar store experience and the physical environment is slowly turning into a space that needs to entertain through social, educational, playful, and multi-purpose means. Instead of a sharp focus on the purchase of goods, the creation of a pleasurable experience takes centre stage [63]. Digital layers and immersive technologies allow for such dispersed user journeys, and we hypothesise that they could be a key aspect of sustainable and circular practices and might help to repurpose consumption by shifting its focus from goods and materials towards services. The abovementioned retail trends and e-consumer habits, as well as design practice, have seen an unprecedented change during the COVID-19 pandemic, which catalysed much of those digitalization processes long announced and/or waited for [64]. Dressing in the digital and attending digital catwalks became not only possible but also claimed as a less material-intensive fashion industry reality [65]. While the industry still attempts to understand its real potential for positive impacts on sustainability and how long-lasting dressing in the digital may be, it is unarguable that the digital experiences have enabled storytelling and building aspiration around fashion products, and this has supported brands to keep connected to their customer base. In short, the digital is regarded as a welcomed extension to physical fashion [66].

Industry 4.0 is giving opportunities for less streamlined and practically bespoke interactions between brand, product, and consumer [67]. The omni-channel approach diffuses moments of interaction and creates a cloud of moments during which emotions, distinctions, information-gathering, and decision-making can take place. This decentralised process of consumption can be overwhelming, yet it can be seen as a positive that its less linear character allows for a more formulated process of product choice and critical engagement with material origins and production processes. However, whilst decentralised and automated production lines allow for active consumers or 'prosumers' [68], the assembly of anything arriving on a shop floor still happens within the factory [69]. A hands-on role

in the production of a product or the opportunity to test, make or physically participate using touch or experiencing material performance and provenance is a latent opportunity, and we see with very few retailers inviting a more active consumer participation.

Revisiting the historic origins of retail in the context of technology allows us to understand the shift in consumer needs and the rising interest in knowing more about the products they purchase. Transparency, an ideal risen from technological advancements and globalisation, is a recent demand of consumers that can be achieved with the help of industry 4.0 tools such as RFID and blockchain (e.g., EON ID [70]). And even if only few consumers start to appreciate it, nurturing traceability and data accessibility for materials will be fruitful if opportunities to experience such information is possible and perceived as a pleasurable moment. As described earlier, the options to participate and learn about products are growing in the most versatile market segments. To cultivate a demand for deeper understanding of materials used in our products and subsequently the wish to ensure their reuse, it is therefore essential to understand the triggers and best practices to create a meaningful relationship between the user and the materials our products are made of. Such a multi-layered context can be created with the help of technological enhancements. The rising adoption rate of these practices in retail situations is a promising development allowing us to imagine scenarios to emerge, as in The Compositor Tool Study presented below.

3. Materials and Methods

The Compositor Tool is a concept tool designed to enable consumer participation in the selection and assembly of materials in their products. The Compositor Tool engages people in multisensory experiences and storytelling involving materials in products to enable consumers to (i) understand biobased circular materials and their reactions to them, (ii) more actively engage in the co-creation of products, and (iii) raise awareness of, and slow down, the process of consumption. The Compositor Tool comprises four stations involving: (1) experiences for selection of materials and configuration of products ('component selection'), (2) storytelling about materials provenance ('material stories'), (3) future life cycles ('material futures'), and (4) embodied explorations of the properties of materials ('materials gym'). We ran this feasibility study using a low-fidelity protocol involving analogue and digital means to enable participants to have a deeper sensory engagement with materials and explore their present form, to explore their provenance and review similar applications), and to explore their future interactions related to performance in different contexts of use and care. Below we describe the processes of design of the tool and the running of a study using the tool.

3.1. Design of the Compositor Tool

For the design of The Compositor Tool, a series of design workshops were carried out to incrementally develop tool concepts involving two authors (a product and a fashion and textiles designer working in academia) and two commissioned product designers (working in industry and academia). A design workshop is a participatory method utilized to creatively address a problem as a team by undertaking specific activities that lead to a proposed solution [71]. In this case, the workshops explored our research question "How can designed experiences catalyse people to become custodians of materials, and therefore stakeholders in material circularity, as a circular design strategy?". Taking together the many instances in which consumers experience a product/brand, with the literature presented above, we defined some points of orientation to focus our design space. Thus, it was decided that:

- Focus on in-store experience—the most conventional point of contact for consumer experience in the current state of affairs;
- Consider blended analogue-digital experiences—as we are now living analogue and digital realities;

- Comply with circular design requirements—long-lasting, high quality, designed to be disassembled [31].

We carried out ideation sessions through which we generated several concepts for tools. These were categorized according to their relevance to design, manufacture, use-repair-update-upgrade, and end-of-life. The tools were then mapped according to these themes, which was aimed at facilitating reflection on the level of consumer engagement at the different stages of a material lifecycle, and to observe their relevance to a particular phase (Figure 1). We then selected the most relevant ideas to deepen/broaden consumers' experience and ran a sketching activity to develop those ideas further. Figure 2 shows the sketches of the initial selection of tools.

Figure 1. Mapping of ideated tools.

Figure 2. Initial sketches for tools.

Through the sketching process, followed by discussions and eventual consensus, the 'Textile Probe' was selected as the most promising concept. We worked in the group to further develop this idea collectively and renamed it the 'Compositor Tool'. The Compositor Tool was designed with a focus on reimagining consumers' ways of customising. A shift that involves new approaches to design, update and upgrade. It does so by presenting new ways of understanding materials' past, present and future to inform how participants can select and configure materials to build their own product. By using analogue and digital means to add extra layers of information, participants were enabled to have a deeper

sensory engagement with materials, and to project them into the past (e.g., unpacking materials' provenance) and into the future (e.g., exploring how materials could behave in use).

To enable experiences of selection and configuration, a consumer-facing interface was developed consisting of a library of component parts and digital-tangible interfaces for navigating the stories of past, present, and future of the materials. These were conceptualized with a focus on designing for compelling experiences, i.e., related to challenge and self-expression, stimulation of the senses and relationship with others [72]. In this case, these aimed at exploring means by which people could participate in the design of products in multisensory, engaging and playful ways. To develop such new interaction types, we needed a product to anchor our investigation. Having circular design as an established requirement, we identified a sandal design, the Assembly-Line 01 (Assembly-Line ©, assembly-line.nl), as the ideal platform to develop from. We were attracted by its reduced and replaceable components (sole, strap and buckle, see Figure 3). We further simplified this design by eliminating the buckle (strap designed to close on itself) and using a single material for the sole.

Figure 3. Original sandal design: Assembly-Line 01 ©, by Marijke Bruggink.

Being inspired by scoping research on circular materials [73], particularly agricultural waste-derived ones, we speculated on materials that we anticipated might emerge. Hence, the two designer-authors created 'hypothetical materials' derived from food industry by-products and waste, that were featured both in sole and strap options. Our chosen materials were all cellulosic, with origin from waste in the processing of sugar beets (named as *Sweet Leather* and *Sweet Sole*), wheat (named as *Celluwheat* and *Wheat Sole*), and citric fruits (named as *Pealtex*). The two designer-authors produced proxy materials (physical examples that represent the 'hypothetical materials') to carry out the studies. We consulted a material circularity expert at the Royal College of Art to better understand aspects of the materials' provenance, processing, and recycling. This consultation further informed the development of graphic elements to be used as projections in the interactions designed around material transformations that could locate consumers in the materials' lifecycle.

The 2 designer-authors and a commissioned designer thus designed experiences for the configuration of products: via immersive storytelling about materials' provenance, future lifecycles, and about the properties of materials. They were delivered through four stations:

1. Component selection: this station aims at allowing for the configuration of products by enabling people to articulate perceptions and preferences via the selection of materials. For this study, each participant could select from three strap and two sole options to create a sandal (modular), which they could carry to the consecutive stations using a tray also available at the station (Figure 4).

2. Material stories: the station aim is to allow for playful engagement in immersive storytelling about materials' provenance. For this study, we designed puzzles containing three steps of the material transformation. The 'puzzle' element was selected as we did not expect participants to have prior knowledge of how materials look, feel or smell on their journey from waste to becoming a new bio-based material. Hence, the shapes of the puzzles were intended to help people in the discovery journey of the material transformation, for example, the journey from an orange peel, through cellu-

lose pulp, to fibre [74]. Once participants assembled the puzzle correctly, a projection would reveal further details of this process (Figure 7).

3. Material futures: this station aim is to enable participants to understand future lifecycles via immersive storytelling. By positioning their selected strap and sole on an interactive table, projections would reveal possibilities for future applications of each material (Figure 5). One example was a sole that was recycled several times and could only be utilized in a composite material for furniture in the next lifecycle.

4. Materials gym: this station aim is to support embodied explorations of the sensory and physical properties of materials. For this study, physical props related to shoemaking process, such as a cobbler's tool, were presented alongside animated videos that showed participants different ways to manipulate and experience materials (Figure 6).

Figure 4. Selection of components.
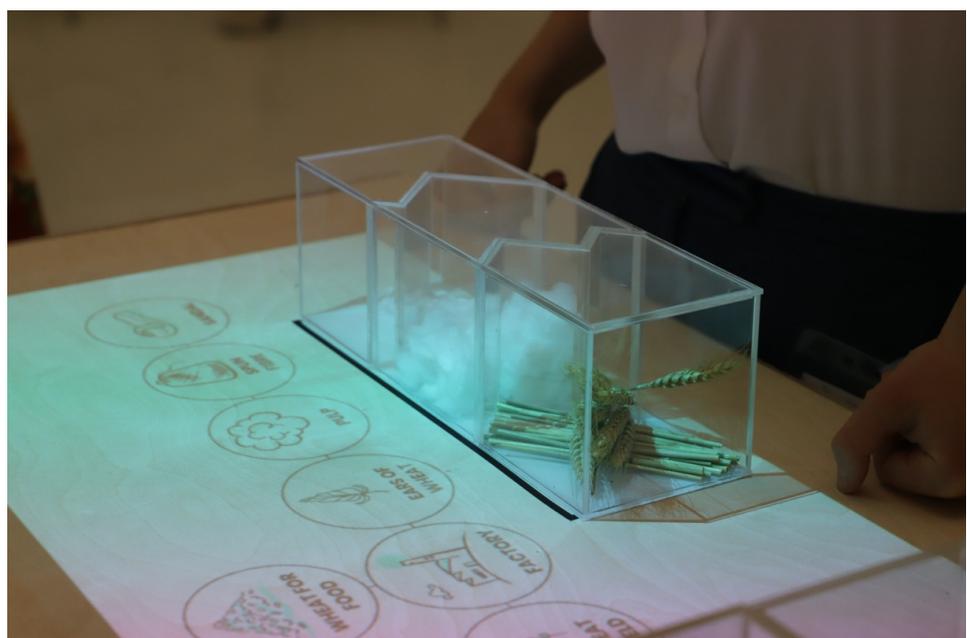
Figure 5. Material Futures.
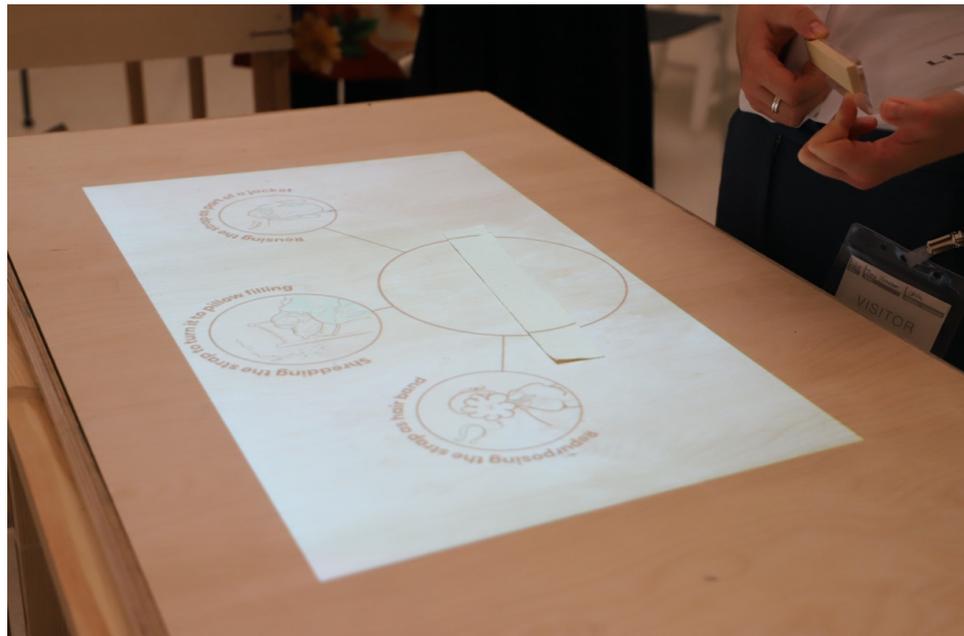
Figure 6. Materials Gym.

Figure 7. Material Stories.

Figure 8 shows a schematic of how these stations were organized in terms of a journey for the consumers to interact with.

Figure 9 shows a top view of the environment that was created for participants to go through this journey.

3.2. The Compositor Tool Study

Further exploring our research question, this user study aimed to test 'The Compositor Tool' to understand if and how new interaction techniques might enable consumers to have more creative and informative interactions that would create a deeper connection between people and products, and the materials in their products.
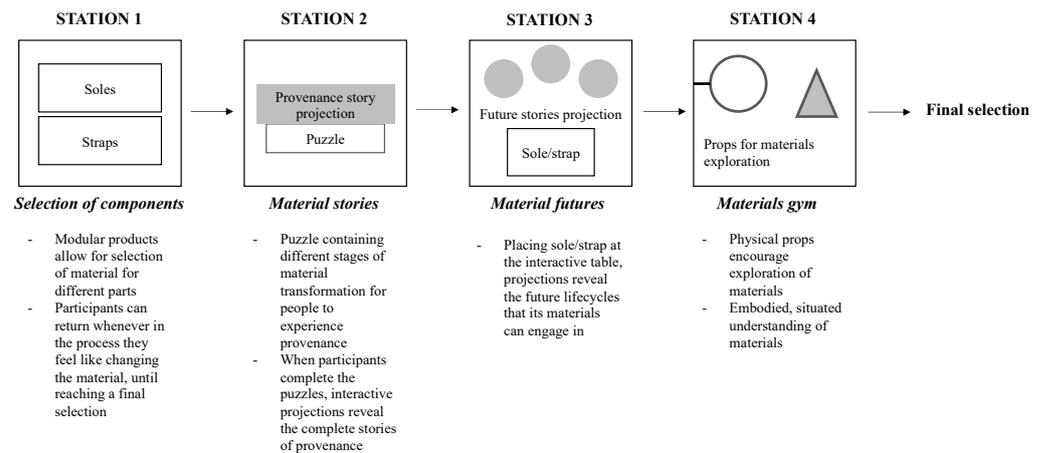
Figure 8. Schematics of the process of The Compositor Tool.

Figure 9. The journey of the Compositor Tool.

A Living Lab [75] methodology was followed to allow for an experiential environment where diverse methods are used to test realities of the future with people and to investigate the designed experiences. The Living Lab methodology was chosen for three main reasons. It enabled us to understand often invisible dimensions of human experience; it facilitated 'design into experience' (exploring new product/brand experiences and novel interaction types), and it allowed observation at micro and macro levels of this phenomena (from the individual sensory perception to the contextual and social implications in researching real world challenges). In the case of the 'Compositor Tool', the Living Lab approach allowed us to investigate in-situ the four designed experiences (stations in Section 3.1) and to observe how consumers can actively participate in the circular textiles' economy.

The studies were conducted at the Hockney Gallery, Royal College of Art. A total of 16 participants (12 females and 4 males) who voluntarily responded to our call experienced The Compositor Tool and contributed their impressions. The participants were mostly young professionals (backgrounds included architecture, design, business, and engineering) and postgraduate students with prior industry experience (backgrounds included fashion, industrial and graphic design), who received this invitation via their working networks. The study was approved by a local ethics committee, and all participants received information

sheets and signed written consent to their contributions being recorded. Participants attended the study individually or in pairs, according to their availability. During the study, participants visited our Living Lab space with the task of selecting the materials for the components that enabled assembly of their sandals, i.e., the strap and the sole. They were invited to freely explore and interact with the four stations that form the Compositor Tool. They took on average 20 min to go through this process, and audio-visual recording was made of this part of the study. After that, they were interviewed by the research team, following a semi-structured interview protocol (see Table 1), and with an average duration of 40 min. The interviews were audio recorded only.

Table 1. Semi-structured interview guide for the Compositor Tool study.

Aspect Being Explored	Question
Description of the experience as a whole	1. If you agree, could you please tell us how was the experience that you just have been through?
	2. What components did you choose?
	3. Can you tell us about your decision-making process?
Exploring discrete experiences	4. What role did the stories of material provenance have on your choice?
	5. What role did the future stories play in your decision?
	6. What role did the sensory properties and performance of materials have on in your choice?
Exploring the quality of experiences	7. Were the ways that the stories were presented engaging?
	8. Did you feel as if you have learned something?
	9. Did the way that the presentations were delivered create an engagement between you and the material?
	10. Would these compel you to take care of the material? Or feel that you are a custodian of the material?
Beyond the study	11. If you were to imagine a future scenario where some of these interactions are presented in retail spaces, is this something you would participate in?
	12. Would you like to have access to these interactions beyond the "Living Lab"? If so, how would you like to store and/or access it? For example, would you like to record things in an app (e.g., Pinterest type), or some kind of digital repository?

All data was transcribed verbatim. The Thematic Analysis method was used for systematic analysis of the data, following Braun and Clarke's [76] guidelines, which suggests that the analysis should follow the six steps described below:

1. 'Familiarising' with the data by reading the transcripts to acquire a general understanding
2. Identifying initial codes by systematically categorising transcripts with labels; such labels should "identify a feature of the data (semantic content or latent) that appears interesting to the analyst" ([76], p. 88)
3. Identifying themes based on clustering the codes generated in step 2
4. Reviewing and verifying if themes do reflect the content of the whole dataset
5. Formalising themes and renaming where necessary, to help construct the narrative the communicates the results
6. Reporting themes with the support of selected quotes

For greater rigour of the process, the data was analysed by two of the authors (from a fashion and textiles and product design background) independently until step 3. The authors then worked together on step 4, as a form of validating the initially identified

codes and cluster of themes. Given the significant overlaps between their codes, they then proceeded with steps 5 and 6 in a combined effort. The report on the themes is presented below.

4. Results

The results obtained from the studies indicated two main themes: '*Deeper connections between people and products/materials*' and '*New interaction techniques enabling consumers to have more creative interactions*'. Each theme was created by a cluster of sub-themes that were constructed through the analysis. These are described below and where participants anecdotal evidence is used, this is indicated with the notation P#.

4.1. Deeper Connections between People and Products/Materials
4.1.1. Product-Led Interaction

Product categories define the type of circular behaviour (e.g., a shoe will be repaired because it is a long-lived piece). Participants had different expectations and criteria for how they wanted their shoe to function, look and feel; some were looking for a light sole-material, some wanted a heavy one, some preferred the look of a leather-like strap, and some preferred the woven textile option. A pattern emerged from the selection process showing a clear difference in the selection of the two component-types, the sole and the strap. Generally, the sole was selected based on reflections around comfort, functionality, and durability. Comfort also played a role in selection of the strap, but this component was often chosen based on aesthetics, how it reflected the identity of the participant and what they wanted to express to others. "For the sole, for me, it was about the weight... The strap was about how it looked." (P6). When participants justified their selections, these different functions of each component played an important role. Some spoke about replacing and customising the shoe by changing the strap, or even gifting it as a present, and this indicated that the strap was often perceived as temporary and exchangeable, and the sole as more permanent and longer lasting.

Product categories determine the level of engagement in novel retail interactions. Participants were more willing to engage with products that are long lasting, products they will buy frequently, or products that are expensive; 'I think there's something around expense and the possible longevity of the item, that makes one want to think more deeply about what it is, how it will be used, how long it'll last and so forth.' (P14). In relation to level of engagement in the acquisition phase, participants described the importance of product longevity for them to want to engage, and as part of this, many participants categorised shoes as a long-lasting product-category and were thus more willing to engage themselves in it; "...it's probably just for certain products, so something you maybe buy for a long time. So, for example, if you buy, I don't know, leather boots, you know, something like winter boots, something that you know that you'll be wearing and that it's an investment and you'll be wearing them for, like, five or six years, then you could probably spend a bit more time on choosing or getting familiar with the materials... I probably wouldn't do it, like, you know, for a t-shirt" (P4).

These indicate that interaction design will need to consider the differences in product type or even product parts, as they will require different kinds of engagement and incentives (e.g., more playful, more educational, more sensorial, etc.).

4.1.2. Full-Circle Relationships

Participants revealed interest in understanding the diverse cycles that materials are engaged in—previous, current and future. In terms of exploring previous cycles, in regard to provenance, participants were interested in quantifying the impact of materials (and consequently their choices) in understandable and comparable scales. This would also be affected by how relatable the story of materials seemed to their own personal stories. As some Participant 4 described: "I just found wheat a little bit more familiar, probably with my past . . . "

Regarding exploring the next cycles, participants (P2, P3, P8, P9, P14, P15) expressed a need to somehow verify and visualise the next cycle through feedback (e.g., if the material will become a table in its next cycle, would you be notified when this table was ready or sold?), and that seemed to play an important role as motivation and incentive for consideration of the next cycle in their choice. "I think it's nice to see that it does have a second life and that it's tangible." (P8).

A smaller portion of participants (P2, P3) would also prefer to register the impact of actions during their time with the material (e.g., did they care well for the material?). They went on to report that a system to know what will happen after their life with the owner would be desirable, otherwise, "You're like, "I hope it gets there." But you don't actually know." (P8). Further to that, a participant highlighted the importance of tangibility, beyond the information. "I think so very much, but rather than knowing, I just want to see. Like, nobody necessarily needs to tell me, you just touch the material." (P14). That presents opportunities for future brand-interaction.

4.1.3. Retail Reimagined

Participants demonstrated a dissatisfaction with current retail experience, deemed overwhelming given the "large range of stuff for you to look at, and also the pressure of people staring at you and expecting you to purchase things" (P6). They particularly highlighted that "retail has been boring for a very long time now because the experience has only, and predominantly, been based on the sense of sight" (P16).

Participants indicated that a different retail experience, such as the one experienced in this study, adds an element of enjoyment, which might be through the stories or the multisensory engagement with materials and their stories. This experience could promote a renewed sense of interest for retail. "I would go shopping again, because I don't go shopping for... like . . . I can't remember how long" (P13).

Participants would prefer to see the retail reconfigured for more immersive experiences and longer interaction (beyond just the physical shop, as was explored in theme 'Full-circle relationships') to support their decision-making process by delivering transparency in experiential ways (P10).

They report that they would visit shops to be educated about materials, and to acquire inspiration (P2, P4, P5, P6, P7). In that sense, they compared their envisioned retail experience as more of a museum-like experience, "I picture, like, lots of catalogues and thousands of samples on the wall, and I can just be there all day. It's like being in an exhibition, you know, you learn about that, as well." (P13).

4.2. New Interaction Techniques Enabling Consumers to Have More Creative Interactions

4.2.1. Participation and Gamification

Participants considered the experience to be somewhat familiar, given the "assemble, customisation shopping experience" (P6), with novelty added by interactions and gamification in the presentation of stories and testing of materials, that was considered fun (P2), interesting (P7), playful and educational (P16), which are seen to engage their "attention on a different level" (P16).

> "*through giving that different experience of actually playing with the material, playing with the product, you can get a much better result. When I'm looking at this and thinking, "Could that be my shoe experience?", that would be wonderful because then it's also customisation to a completely new level because you're choosing all the materials, but you're also understanding where they're coming from. So, you're making that conscious consumer decision.*" (P16).

Participants also acknowledged that the simple design of the shoe facilitated the participation, as "There is nothing that is a barrier to entry" (P1), and that complexity in design might be a barrier and would require more gamification—"With more components, more complexity, that is the sort of thing that gets gamified, isn't it?" (P1). The participants recognised how engaging more deeply with the materials, and learning about them through

different activities, created a sense of awareness of the importance of their decision-making process. Further, this increased participation facilitated that process in the sense that they felt more committed to making a sound decision. This decision-making created a sense of satisfaction, where participants considered that "if you are making the choice of being a responsible consumer, then that sort of procedure satisfies, to an extent, and helps you make that decision in the process" (P11).

4.2.2. Meaning-Making through Storytelling

The stories and storytelling around the materials enabled participants to relate their personal history and experiences that approximates them to the materials (P1, P2, P5, P8, P10, P12). This was noted in, "I like this material because it looks pretty, and, okay, this looks comfortable and it looks perfect to be my shoes," but then, after that, it feels like, "Okay, this is from wheat. Wow, that's interesting. That is a thing that I eat every day," you know, in my culture. It's, like, "Okay, that's more interesting"" (P12). They also recognise the importance of creating a meaningful emotional experience through the stories that enable connection with the materials, "And the things I want to engage with are, like, something more emotional, maybe, more story. Yes, because, like, you're not going to remember everything . . . " (P12).

The storytelling facilitated by the technology interventions, alongside the physical props, enabled participants to understand the material provenance and the steps of transformation, which is both educational and creates surprise (P2, P4, P7), and ultimately, "I think it just satisfied my curiosity, knowing where it came from" (P11). Participants mentioned that getting to know the stories of materials makes them think through and consider more the different cycles that a material participates in (P4), and this enabled them to gain perspective, which is again related to making an informed decision (P7).

The participants showed great interest in gaining access to even more information about the materials, but suggested that this access should be created through different levels or pathways (e.g., "Perhaps you can layer the information for more inquisitive consumers so that you don't overpower with information those that are not interested in it" (P16)), and with different entry points (e.g., some people may be more sensory driven, and need to feel materials first, and access information later) (P2,P3,P4,P5,P7,P10). That additional information could include more contextual information about materials (e.g., availability, social aspects of materials' obtention), as well as on their manufacturing/processing (e.g., emissions, scalability).

> "So, I'd like to have known a bit more . . . About the process of the impacts of doing that. So, even though you're processing part of the wheat, is it actually a higher impact than if you throw it away and created these shoes in a different way?" (P6).

Finally, participants recognise that storytelling creates a sense of caring for the material and commitment, "Because it's, kind of, like, building a relationship with the material itself, like, the materiality, yes, of the products." (P13), and taken together, these increase the perceived value of the product,

> "I guess because there is this higher perceived value you are tempted to take care of it more, because you know that there are many people who actually in a way have participated into this process of you having these shoes at this moment, from farmers to manufacturers" (P10).

This sense of caring for the materials speaks to the notion of custodianship, which is so important for a circular economy as a basis for circular practices to become mainstream.

4.2.3. Making Sense of Materials

Participants were very absorbed by exploring properties and understanding materials from experience. This was facilitated by the playfulness of the activities,

> "this one is, like, it's, kind of, fun, it's like a gym with the material and I can remember everything, every detail in this part. So, for me, it's really enjoyable, yes. And this part,

it's the most influential . . . (...) like, the most important thing that made me choose two of the materials." (P12).

They reported feeling creatively stimulated:

"*it's almost like a workshop kind of scenario where you're presented with a few things and you're like, 'I want to play and see how it works here, how it works here.' It's good because it also stimulates your creativity.*" (P16).

Participants seemed to be at the same time learning about the materials, understanding them, and adjusting expectations (P3, P4, P5, P6, P7), all because these were new materials to them, and "You kind of want to take that material to the extreme, so if you can stretch it, how far can I really stretch it to be very convinced?" (P11). In exploring the properties, participants not only become familiarised with the materials in relation to their personal preferences (e.g., "(...) because each one of the consumers, they have their own peculiarities, like in terms of products, so some . . . My thing with a flip-flop is that the material, the strap, I don't want it to give me blisters" (P16)), but also learn about what they should expect in terms of taking care of the materials (P1, P5, P6), as

"*It allows you to test for it, almost, and learn how you could understand the ways how you can take care of that material (...) it allows you to understand what your commitment will need to be to the material, to the product, in order to maintain it for as long as possible*". (P16).

They can engage with the material at this more experiential level, and from this standpoint they are able to project into the future and make assumptions about how the materials will be part of their lives, in their daily practices. Participants showed an increased engagement with the materials, which they also attribute to the fact that the possibility of feeling the whole story of the material enhanced their connection and presented plenty of possibilities for even more engagement, "I think that's a lot of sensory potential, touching and feeling the whole story" (P11).

4.2.4. Flow between Physical and Digital Experience

A mix of physical and digital media were combined to form a retail experience in this study. The digital components were designed as an additional layer of information displayed over the physical elements, such as the sandal components. When asked to describe their retail experience in the Living Lab, many participants used words such as 'fun', 'playful', 'interesting' and 'enjoyable', and even perceived the experience as altering their perception of time ("All of a sudden, I'm in your store for much longer than I would have been otherwise" (P16)).

Participants pointed out that digital elements, such as the interactive projections displaying scenario stories regarding components' provenance and possible future use-cycles, encouraged them to gather information to help guide their decision-making process: "So, it was quite good that you got to go back and forth, depending on the new information you received." (P7). They found the interaction with the digital elements intuitive and used them to visualise and explore information; "I also did, out of curiosity, want to test everything and to touch everything." (P10). The digital elements were designed to recognise each shoe-component and display information specific to each of them. One participant described their experience "Like Shazam for clothes" (P11), referring to an App that can identify music based on a short sample played, using the microphone on the device; a super swift, intuitive way to gather information about something the user is interacting with in that moment.

5. Discussion

The Compositor Tool asks consumers to become prosumers who co-create the final version of their product, engaging in central decision making and allowing the testing and modifying of a product on a level where relationship and interdependence of complex information can be embedded in the DNA of the product. This enhances not only the

user experience but the embodied value. We developed this concept tool and ran a user study with it, to explore our research question: "How can designed experiences catalyse citizen-consumers to become custodians of materials, and therefore stakeholders in material circularity, as a circular design strategy?" Through the study we observed if and how new interaction techniques might enable consumers to have more embodied, creative, and informative interactions, and have a deeper connection with products and materials.

New interaction techniques enabling consumers to have more creative and informative interactions

Engaging in activities that have been designed with *'Participation and Gamification'* in mind through multisensory interactions facilitated by the physical props and digital artefacts, gave participants a greater sense of awareness of the importance of their decision-making process, as well as making them feel more engaged with the creative process; they further acknowledged that this process made things more accessible to them, i.e., without any requirement for prior knowledge or expertise.

Participants recognised that storytelling creates a desire to care for the material and commitment to it, because it opens up opportunities for familiarity to develop, and for meaning to be created through past experiences or the experiences being lived through during this co-creative experience. *'Meaning-making through storytelling'* seems to increase the perceived value of the product. Additionally, participants pointed out that the mix of physical and digital artefacts, creating a *'Physical and digital experience flow'*, such as the interactive projections displaying scenario stories regarding components' provenance and possible future use-cycles, encouraged them to make informed choices.

'Embodied engagement with materials facilitates creative interactions'. Technology is a promising tool that can reinforce physical interactions in retail spaces; it can be the tool to deliver experiences of participation, gamification, and storytelling. Immersive and sensual, it can be key when reintroducing consumers to a full body experience in engagements with materials, where body and mind are equally important. The now available technological enhancements (VR, AR, MR, AI, etc.), however, are easily abused. This is because they can be used to streamline users into paying more for a product due to value being artificially heightened with their help, or trick users into purchase through an entertainment factor. As a response and to steer away from such predominantly consumption-enhancing usage of immersive technologies, we suggest that immersive experience takes place not only in the retail contexts, but also before and after, and with a focus on informing consumers about the materials' circularity and the creative opportunities for circular practices, e.g., customisation, repair, update, and upgrade. This also creates new opportunities for omnichannel experience design, where technology facilitates the addition of a digital layer of information and sensory stimuli to support, enhance and extend the retail experience.

These findings start to scratch the surface of the problematic of the limited research existing on the space of enabling consumers to actively participate in circularity [1]. Moreover, it provides insights that are specific to the moment of acquisition, which had been highlighted as a gap [12]. The themes of participation and gamification, storytelling and embodied engagement offer more specific areas of interest to explore further when designing in this space [1].

Deeper connections between people and products/materials

Product-type defines interactions and indicates that interaction design will need to consider the differences in product type or even product parts, as they will require different kinds of engagement and incentives (e.g., more playful, more educational, more sensorial, etc.).

Stories about provenance and possible futures of product are critical to nurturing *'Full-circle relationships'*, i.e., relationships were consumers have a sense of the whole life-cycle of the materials and are more aware of their role in this lifecycle. Many brands are incorporating provenance information about products on their websites and in retail stores. Currently, this information tends to lack detail or uses information which can only be interpreted by experts and is generally communicated in a way to which users are unable to relate. In this study we have started to investigate a more accessible means to communicate

this information to consumers through experiential, embodied ways, and that has helped in framing some important questions about designing interactions for this purpose in the future: What information is given to whom? How detailed and expert should the information be? How is the information presented? To what degree do consumers trust this information? What are the opportunities for people to act based on this information? The study revealed how making material lifecycle information tangibly accessible to consumers is critical in building meaning and trust.

Participants would prefer to see the *'Retail re-imagined'* for more immersive experiences that educate them about materials, that inspire them, and ultimately support their decision-making process. Multimodal interactions (with physical and digital artefacts) can help people to reflect on materials. They can explore questions such as: will this material perform in my daily practices? Can I see myself looking good and expressing myself when I wear this shoe and material?

These findings are aligned with transformations underway in the fashion sector [56–59] and highlights the opportunities for empowering consumers to drive changes towards a circular economy from being enabled to make better choices to becoming custodian of materials [37]. As was highlighted through the literature, a new role for consumers presents many opportunities, which so far have been little researched in relation to fashion products [38–43]. This paper offers some initial insights that help motivate the argument for more research to be undertaken in this area.

Distancing and alienation from products are understood as an issue [22], resulting in overconsumption and waste. The outcomes in this start to demonstrate how it is possible for design, from the moment of acquisition, to bring consumers to experience a deeper connection with materials, providing a more experiential contact with materials through storytelling and bodily engagement. Interfering at the moment of acquisition has the potential to redefine consumers' relation to products and materials from the outset.

We have also observed some limitations to this concept model that are worth noting: Firstly, people tend to stick to the product they 'fell in love with' because of how it looked and felt, despite what information they were given about provenance and possible futures. This highlights the importance of the design of experiences and products. Secondly, in designing such interactions researchers/designers must be careful not to fall into the luxury/exclusive trap, and create customisation as another tokenistic solution, and not to use entertainment as a tool to persuade people to buy more. These would go against the aim of promoting a shift in consumer culture towards more sustainable practices.

We are proposing is to bring about new circular, cultures around products, and multimodal technology can help here. If we are talking about a circular system, the retail moment is only a grain of sand in the desert; we need to look at the circular consumer experience and bring technology in at different moments to support this transition and transformation. A greater understanding of the circular consumer experiences will be critical in this. Instead of the consumer or the current model of the prosumer, we would prefer to consider scenarios through which we can ensure that the citizen-consumer performs tasks to prolong or partake in the product life cycle. And whilst such form of agency might seem laborious at first, we sense that a culture where the individual is allowed to participate will be the one most likely to produce a future of truly circular material experiences.

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